National Park Service
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National Capital Region Network 2008 Deer Monitoring Report

Natural Resource Technical Report NPS/NCRN/NRTR—2009/275

ON THE COVER
Doe and Fawn at Great Falls, Maryland along the Chesapeake and Ohio Canal National Historical Park (CHOH)
Photograph by: Thomas Paradis, NCRN I&M Program

National Capital Region Network 2008 Deer Monitoring Report

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All manuscripts in the series receive the appropriate level of peer review to ensure that the information is scientifically credible, technically accurate, appropriately written for the intended audience, and designed and published in a professional manner. This report received informal peer review by subject-matter experts who were not directly involved in the collection, analysis, or reporting of the data.

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Contents

Figures

Tables

Page

Appendices

Executive Summary

In 2000, the National Capital Region Inventory and Monitoring Network (NCRN) initiated a deer monitoring program to collect information on deer densities. The program is carried out through fall spotlight surveys in Antietam National Battlefield, Catoctin Mountain Park, Chesapeake and Ohio Canal National Historic Park- Gold Mine Tract, George Washington Memorial Parkway – Great Falls Park, Manassas National Battlefield Park, Monocacy National Park, National Capital Parks – East (Greenbelt and Piscataway units), Prince William Forest Park, and Rock Creek Park. Pellet-group counts are used in Harpers Ferry National Historic Park because of the lack of a road network. This report summarizes and analyzes the fall 2008 spotlight surveys and the 2008 fall-winter pellet-group count.

Deer populations in the NCRN have become a significant negative factor adversely affecting native forest vegetation and other wildlife. The primary negative effect is a reduction of forest regeneration. This means that there will not be any young trees to replace the forest overstory if the overstory is removed by natural causes (fire, windthrow, disease, etc.). The accepted scientific threshold for densities to impact tree regeneration is 8 per square kilometer or 20 per square mile. The lack of shrubs and young trees results in little or no nesting cover for ground-nesting bird species.

Information on deer density and sex ratios is collected during the survey. Both of these measures contribute information about the abundance and structure of the deer population, though density remains the single most important piece of information to indicate if the deer population may be impacting forest vegetation.

All park units sampled except had densities indicating overpopulation.

In 2008 there were five parks with buck:doe ratios that would indicate an overpopulation situation. Only one park had such a ratio in 2007. The number of parks with low fawn:doe ratios increased from one in 2007 to five in 2008.

All NCRN parks currently have or have had deer density levels that indicate deer abundances that interfere with forest regeneration and associated wildlife habitat.

Introduction

White-tailed deer (*Odocoileus virginianus*) are considered an important stressor on forests of the National Capital Region. Factors such as fire suppression, the rapid spread of invasive, exotic plants and overabundant deer populations are working in concert to alter the regeneration, and hence, the natural successional pathways of the forests in the region (Rooney et al. 2004, Nowacki and Abrams 2008).

White-tailed deer densities throughout the eastern deciduous forest zone increased rapidly during the latter half of the 20th century and may now be at historically high levels (McCabe and McCabe 1997). McCabe and McCabe (1997) estimate that pre-European deer densities in the eastern United States ranged between 3.1 and 4.2 /km^2 in optimal habitats. Today, examples of deer populations exceeding 20/km^2 are commonplace (e.g. Knox 1997, Russel et al. 2001, Augustine and deCalesta 2003, Rossel Jr. et al. 2005, Griggs et al. 2006, McDonald Jr. et al. 2007).

There are many reasons for the rapid growth of deer populations (Côté 2004). After the near extirpation of white-tailed deer early in the 20th century, public agencies began creating game reserves and managing deer populations. Governments established laws that regulated the hunting of deer which led to population increases (Diefenbach et al. 1997, Brown et al. 2000). The elimination of large predators led to further increases in deer populations (Côté 2004). Over the past 50 years, improved silvicultural techniques, fragmentation of forests for suburbs and abandonment of agricultural lands led to increases in available forage for deer (Alverson et al. 1988, Porter and Underwood 1999). Further, declines in hunting in suburban areas left deer populations to grow unchecked. These overabundant deer populations are promoting a host of negative impacts on the structure, composition and dynamics of the eastern deciduous forests.

Deer can alter forest composition and succession by inhibiting the regeneration of preferred species likes oaks (*Quercus* spp.) and hickories (*Carya* spp.) and thus allowing new, less palatable, species to dominate (Frelich and Lorimer 1985, Tilghman 1989, Horsley et al. 2003). Less palatable herbaceous plants such as ferns, grasses, *Vaccinium* spp. and mountain laurel (*Kalmia latifolia*) often spread and create extensive ground cover that further inhibits regeneration of woody and herbaceous species (George and Bazzaz 1999, de la Cretaz and Kelty 2002, Royo and Carson 2006). Deer reduce or eliminate populations of many forest herbs by stifling growth and reproduction (Rooney and Dress 1997, Augustine and Frelich 1998, Knight et al. 2009) and they have been shown to reduce understory diversity (Gill and Beardall 2001). Browse intolerant herbs tend to be smaller less likely to flower and have higher rates of mortality (Augustine and Frelich 1998). Plants intolerant to browsing have, over time, shown population declines or even local extirpation (Rooney and Dress 1997).

Altering the structural complexity of the shrub layer has reduced populations of forest nesting birds by eliminating nesting habitat (deCalesta 1994, McShea and Rappole 2000). Deer can cause declines in populations of small mammals by reducing the availability of mast (McShea and Schwede 1993, Ostfeld et al. 1996). By altering the plant community composition, they have been shown to alter insect community composition (Haddad et al. 2001). They cause significant damage to private property such as landscaping (West and Parkhurst 2002), vehicles (Romin and Bissonette 1996) or forests managed for wood. They can impact agriculture by reducing crop yields (Conover 2001, Stewart et al. 2007) or damage plant nurseries and orchards (Lemieux et al. 2000). Deer and tick (*Ixodes dammini*) densities have been shown to move in tandem which may lead to increases in zoonotic diseases such as Lyme's disease (Wilson et al. 1990, Deblinger et al. 1993) though other factors have also been implicated regardless of deer density (Amerisinghe et al. 1993; Ostfield et al. 2006). Deer are also carriers of diseases such as chronic wasting disease (Williams et al. 2002). They can alter availability of nutrients in the soil (Pastor and Naiman 1992, Hobbs 1996, Ritchie et al. 1998) and ultimately, overbrowsing can lead to alternate stable states (Stromayer and Warren 1997, Augustine et al. 1998) whereby relative abundance of preferred species and successional direction is altered. These alternate stable states often are not reversible even when deer populations are lowered (Westoby et al. 1989, Scheffer et al. 2001).

It is difficult to determine when a deer population is overabundant. Caughley (1981) defined four categories of overabundance: 1) when the animals threaten human life or livelihood, 2) when the animals depress the densities of favored species, 3) when the animals are too numerous for their own good, and 4) when their numbers cause ecosystem dysfunction. So, how do we know when a deer population is overabundant? Alverson et al. (1988) claim that densities as low as 4 deer/km^2 can prevent regeneration of some woody species. Tilghman (1989), based on enclosure studies in Pennsylvania, recommends deer populations be maintained below 7 deer/km^2 to prevent regeneration failure and Horsley et al. (2003) demonstrate negative impacts on vegetation at densities exceeding 8 deer/km^2. For the purposes of our vital signs monitoring we use the threshold of 8 deer/km^2 (Bates 2006). Our monitoring currently shows that 11 parks in the NCRN exceeded this threshold in 2008 (range = 11 to 77/km^2, Bates this document). Our monitoring also shows that many parks have fewer seedlings than would be expected (Schmit and Campbell 2008). Deer are likely causing significant impacts throughout the National Capital Region Network and for this reason are a primary management concern for the parks throughout the region.

The NCRN uses Distance surveys (see Methods) and pellet-group surveys to estimate densities of white-tailed deer throughout the network. Monitoring started in the fall of 2000 and is conducted annually at Antietam National Battlefield (ANTI), Catoctin Mountain Park (CATO), Chesapeake and Ohio Canal National Historical Park (CHOH), Greenbelt Park (GREE), George Washington Memorial Parkway (GWMP), Harpers Ferry National Historical Park (HAFE), Manassas National Battlefield Park (MANA), Monocacy National Battlefield (MONO), Piscataway (PISC), Prince William Forest Park (PRWI), and Rock Creek Park (ROCR). Our objective is to document the trends in deer populations at these parks over time. This data can support other monitoring efforts in the NCRN such as forest health monitoring, and exotic species monitoring to gain a better understanding of the condition of the forests. This information can also feed into park management goals and plans.

Methods

Field methods for collecting Distance data and analyzing the data followed NCR Distance Protocols described in the monitoring plan for the region (NPS 2005). All analyses were done at the Center for Urban Ecology (CUE). Spotlight data was entered into Distance software (Thomas et al. 2006). Most parks were surveyed for at least three nights (Table 1). MANA and MONO were surveyed for two nights; GWMP and PRWI were sampled for 5 nights. Each night was treated as a replicate and the data were pooled for analysis. For the initial analysis, the detections were divided into 10-12 evenly-divided distance intervals. Intervals were expanded, narrowed, or dropped from the analysis to produce a smooth shoulder as the distance from the observer to the deer increased. Once a satisfactory shoulder was produced, four models were fit to the data (uniform, half-normal, hazard rate, and negative exponential). The three criteria used to choose the best fitted model were: 1) percent coefficient of variation (CV) less than 20; 2) the detection probability variation was less than 30%; 3) lowest Akaike's Information Criterion (AIC) score. Program Distance calculates all three measures.

Pellet-group counts were used to derive densities in HAFE. Maryland Heights is analyzed on an annual basis. The other sections of the park were analyzed in 2001 and 2007. The 2001 survey showed that deer densities were not a problem outside of Maryland Heights. The 2007 survey showed Loudon Heights with a mild overpopulation situation (11.74 per square kilometer).

Fifty-seven pellet-group plots were checked in the Maryland Heights section of HAFE. The plots are 44-inch circular (1/1000 acre) plots. Deer pellets were removed in December and early January. Plots were checked for deer pellet-groups (group $\geq$ 5 pellets) 90-97 days later. A Bonferroni test was used to test for significant differences between the different dates that plots were checked. None were found so all of the data was included in the pellet-group analysis. Density calculations followed Davis (1982).

Table 1. Survey history of parks using Distance.

Park	Park Code	Number of Fall Surveys – 2008	Year of First Fall Survey
Antietam	ANTI	3	2001
Monocacy	MONO	2	2001
Piscataway	PISC	3	2001
Greenbelt	GREE	3	2001
Manassas	MANA	2	2000
Catoctin	CATO	3	2000
Great Falls	GWMP	5	2001
Gold Mine Tract	CHOH	3	2000
Prince William	PRWI	5	2001
Rock Creek	ROCR	3	2000

Program TRENDS (Gerrodette 1987) was used to calculate the power of the test to detect a trend in the deer population. TRENDS is a software program that gives power estimates using appropriate tests. This is important since we want to be able to gud against not being able to detect a change in the population when it actually has occurred (a Type II statistical error). At a minimum we would like to be able to have an 80% chance to detect a 10% increase or decrease in the deer population. Wide variations in the number of deer groups encountered during the survey is the main reason why a survey would have low power.

The mean fall CV from Distance was used as an input into Dr. Underwood's Process and Power programs to account for temporal count (process variation) and sampling variation. Temporal count variation is high when there are wide variations in mean fall densities over time. Sampling variation is high when there are wide count variations within a survey year. Total CV was input into TRENDS. Other TREND parameters include: an exponential model (changes in deer populations tend to be multiplicative rather than additive); a 2-tailed test because we are interested in decreases and increases in the population; an alpha level of 0.05; a 0.10 rate of change, and study duration (either 7 or 8 years depending on whether or not data was gathered during the fall of 2000).

SYSTAT PC was used to perform linear regression of the logarithm of the total population against time to check for significant population trends over time. For this report, and for all subsequent reports, a p-value of 0.05 has replaced 0.01. This was done to insure consistency throughout the report. For some parks this will have the effect of lowering their power to detect a trend. It will also make it easier for some parks to have statistically significant increases or decreases. The 0.05 level is typically used in scientific studies to guard against a Type I error (rejecting the null hypothesis when it is actually true – for our purpose, stating that there is a population trend when it does not exist). The p-value of a statistical significance test represents the probability of obtaining values of the test statistic that are equal to or greater in magnitude than the observed test statistic. A p-value close to zero signals that your null hypothesis is false and typically that a difference (trend) is very likely to exist. Large p-values closer to 1 imply that there is no detectable difference for the sample size used (no trend exists).

Results

2008 Regional Densities

Table 2 shows the 2008 fall densities for all parks. All parks had densities that exceed 8 deer per square kilometer (20 deer per square mile). Densities above 8 deer per square kilometer exert a negative effect on vegetation (Horsley et al. 2003). Densities above 16 deer per square kilometer (40 per square mile) indicate negative effects on other wildlife species (deCalesta 1999).

Table 2. Fall 2008 densities at NCR parks.

Park	Density (sq km)	95% CI
ANTI	52.71	40.96-67.83
MONO	77.26	37.78-158.02
PISC	58.20	42.20-80.27
GREE	39.14	28.76-53.27
MANA	62.81	28.18-139.98
CATO	44.13	37.26-52.26
GWMP	25.62	16.15-40.65
CHOH	45.17	25.48-80.06
PRWI	11.7	6.78-18.75
ROCR	25.94	17.51-38.41
HAFE (MD Heights	29.85	20.38-43.78

CATO was the only park that had a significant trend in 2008.

Table 3. Percent population change, p-value, and power to detect a ±10% trend.

Park	% Change[1]	P-Value[2]	% + Power[3]	% - Power
ANTI	50	0.33	100	94
CATO	38	0.016*	100	100
CHOH	35	0.08	100	100
GREE	17	0.13	81	61
GWMP	24	0.90	56	38
MANA	10	0.64	100	100
MONO	31	0.24	100	100
PISC	35	0.94	98	87
PRWI	24	0.12	31	21
ROCR	9	0.78	96	82

[1]Absolute difference between first-year density and current density divided by first-year density.

[2] The probability of obtaining a value of the test statistic at least as extreme as the one that was actually observed, given that the null hypothesis is true. Values with one asterisk are significant at the 0.01 level.

[3]Power to detect a 10% trend with a goal of 80% power. "+ POWER" denotes power to detect an increase in a trend. "- POWER" denotes power to detect a decrease in a trend. It is generally more difficult to detect a decreasing trend in population because there are fewer samples in the population to be counted; hence, more surveys would be needed to increase the power to detect a decline.

Sex Ratio Results

Table 4 contains buck:doe ratios from fall spotlight surveys. Buck:doe ratios of 1:4 or more may indicate an overpopulation situation (Miller and Marchinton 1995). MONO has exceeded this figure every year. CATO, ANTI, CHOH, GWMP, and PISC have exceeded this figure in six out of eight surveys.

Table 4. 2001 - 2008 buck:doe ratios.

Park	2001	2002	2003	2004	2005	2006	2007	2008
ANTI	1:9.00	1:5.22	1:3.06	1:3.54	1:8.12	1:17.30	1:7.76	1:6.25
CATO	1:13.00	1:3.11	1:7.03	1:9.30	1:12.20	1:11.80	1:16.80	1:3.45
CHOH	1:5.40	1:3.40	1:6.00	1:6.57	1:6.60	1:6.58	1:2.15	1:4.85
GREE	1:3.61	1:3.47	1:8.00	1:2.76	1:9.00	1:3.31	1:3.72	1:2.80
GWMP	1:4.92	1:5.23	1:2.33	1:23.00	1:5.90	1:2.33	1:4.57	1:4.25
MANA	1: 9.66	1:5.75	1:7.09	1:4.00	1:8.50	1:3.47	1:3.05	1:5.26
MONO	1: 11.40	1:5.22	1:6.13	1:7.12	1:6.50	1:8.60	1:5.90	1:4.36
PISC	1:5.41	1:2.70	1:7.83	1:4.52	1:8.00	1:11.60	1:6.80	1:3.05
PRWI	1:4.76	1:6.16	1:7.50	1:4.40	1:1.91	1:5.26	1:3.52	1:1.54
ROCR	1:2.87	1:5.30	1:2.69	1:4.76	1:3.26	1:4.42	1:3.45	1:3.05

Fawn: doe ratios (Table 5) of 0.3:1 or less indicate populations under stress (Miller and Marchinton 1995) (not enough desirable food sources for does to produce twins). CHOH, GWMP, MANA, and PRWI had ratios less than 0.3:1. ANTI, MONO, and PISC have exceeded 0.3:1 every year.

Table 5.2001 - 2007 fawn:doe ratios.

Park	2001	2002	2003	2004	2005	2006	2007	2008
ANTI	0.74:1	0.91:1	0.86:1	0.80:1	0.41:1	0.70:1	0.39:1	0.41:1
CATO	0.37:1	0.44:1	0.41:1	0.30:1	0.08:1	0.33:1	0.13:1	0.41:1
CHOH	0.13:1	0.17:1	0.56:1	0.52:1	0.10:1	0.11:1	0.32:1	0.05:1
GREE	0.25:1	0.22:1	0.63:1	0.46:1	0.56:1	0.58:1	1.14:1	0.76:1
GWMP	0.23:1	0.28:1	0.76:1	0.26:1	0.03:1	0.14:1	0.32:1	0.21:1
MANA	0.63:1	0.27:1	0.45:1	0.34:1	0.35:1	0.21:1	0.31:1	0.29:1
MONO	0.66:1	0.93:1	0.87:1	0.59:1	0.38:1	0.33:1	0.38:1	0.77:1
PISC	0.37:1	0.48:1	0.86:1	0.69:1	0.62:1	0.62:1	0.97:1	0.64:1
PRWI	0.16:1	0.19:1	0.38:1	0.00:1	0.08:1	0.07:1	0.35:1	0.21:1
ROCR	0.12:1	0.25:1	0.75:1	0.39:1	0.30:1	0.38:1	0.53:1	0.35:1

Park Results

Antietam

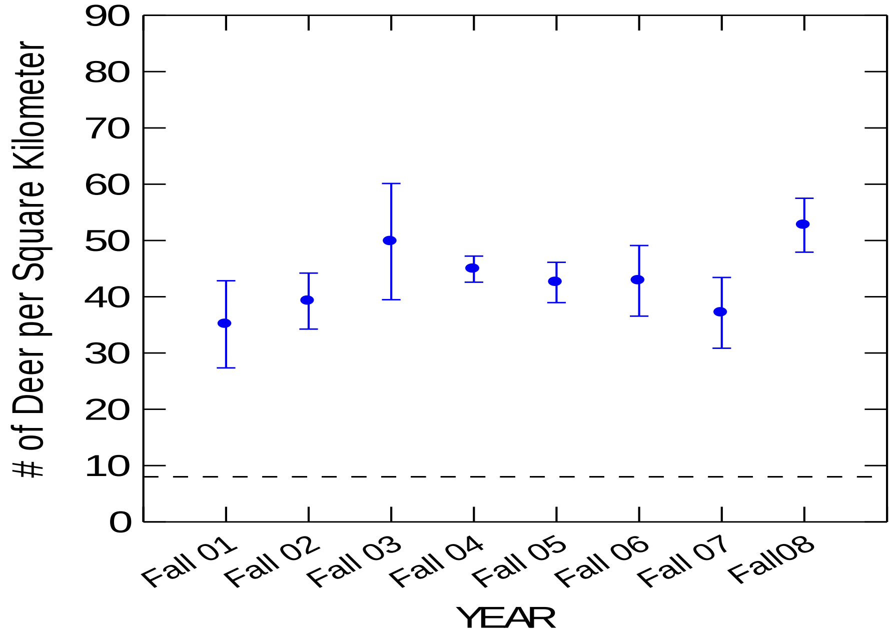

Figure 1. Antietam National Battlefield annual density.

If the standard error bars overlap then there is no significant difference between years. The park recorded its highest density ever, increasing by 40% over 2007. There was no significant population trend between 2001 and 2008. The dotted line represents the recommended forested deer density of 8 deer per square kilometer.

Monocacy

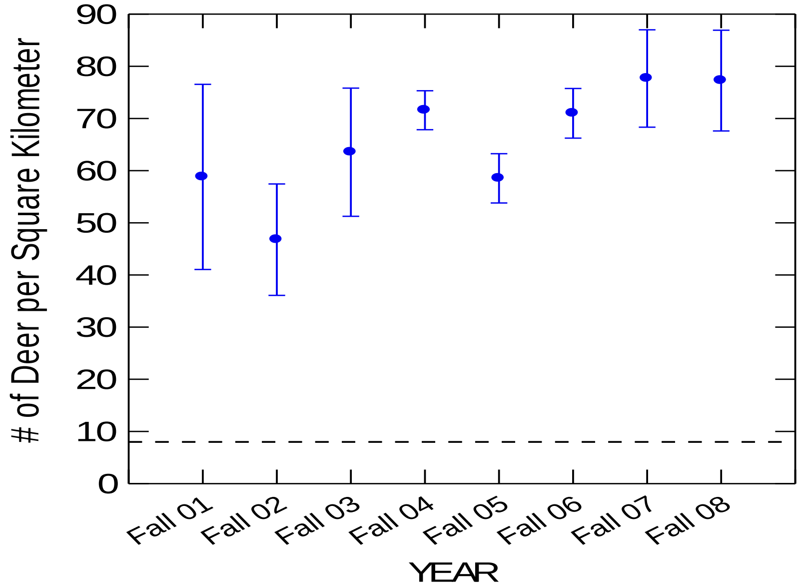

Figure 2. Monocacy National Battlefield annual deer density.

Monocacy's deer density increased by 9% from 2007. The park had the highest density in the region in 2008 and continues its streak as one of the top 3 high-density parks in each year of the survey. There was no significant population trend during 2001-2008.

Piscataway

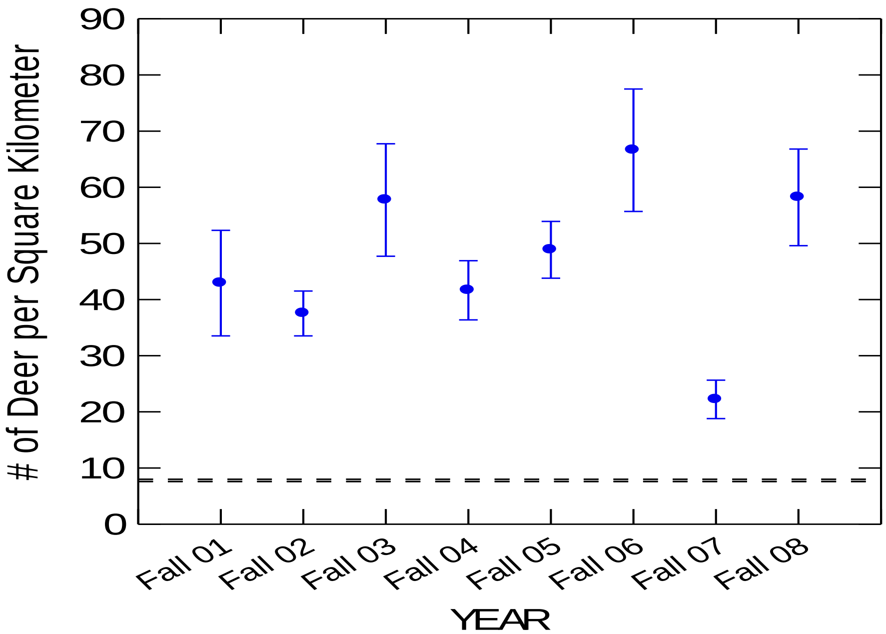

Figure 3. Piscataway Park annual deer density.

The deer density at Piscataway increased by 162% from 2007 as the population rebounded from the 2007 outbreak of epizootic hemorrhagic disease. There was no significant population trend from 2001-2008.

Greenbelt

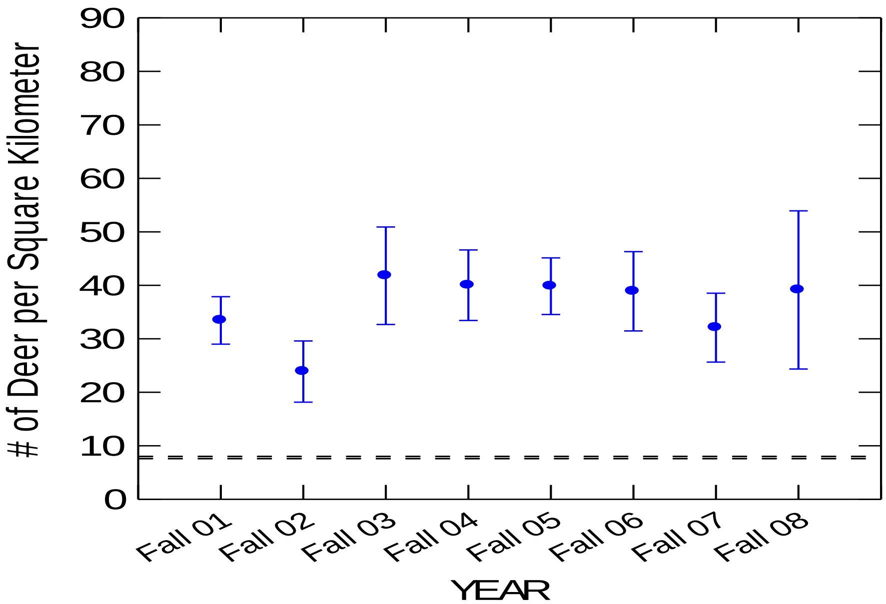

Figure 4. Greenbelt Park annual deer density.

Density increased by 21% over 2007. There has not been any significant trend at Greenbelt during the study period. Power to detect a 10% increase is 91%; it is 76% to detect a 10% decrease.

Manassas

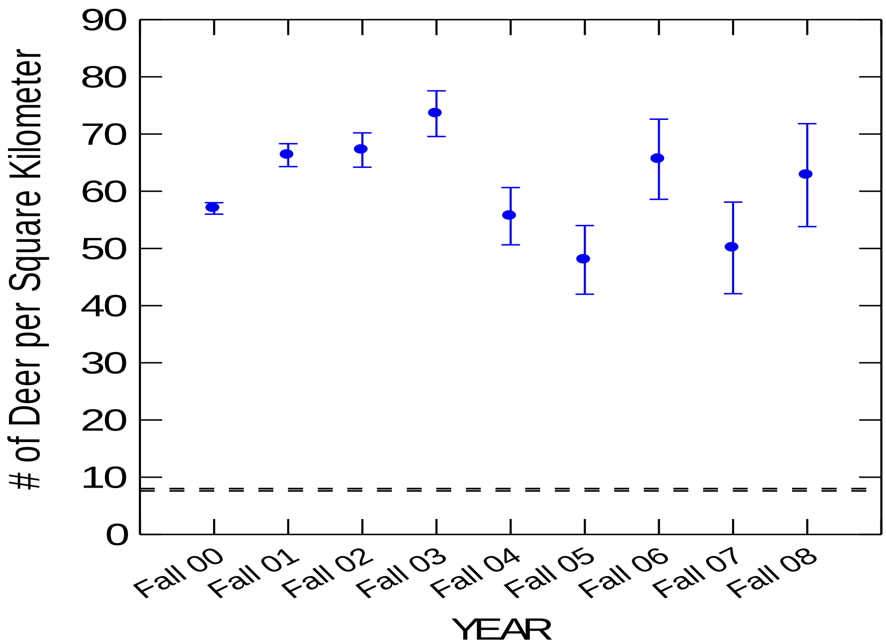

Figure 5. Manassas National Battlefield annual deer density.

Manassas increased by 25% in 2008. It also had the second highest density of all NCR parks. No significant trend was detected during the study period (2000-2008). MANA has achieved 100% power to detect a ±10% trend.

Catoctin

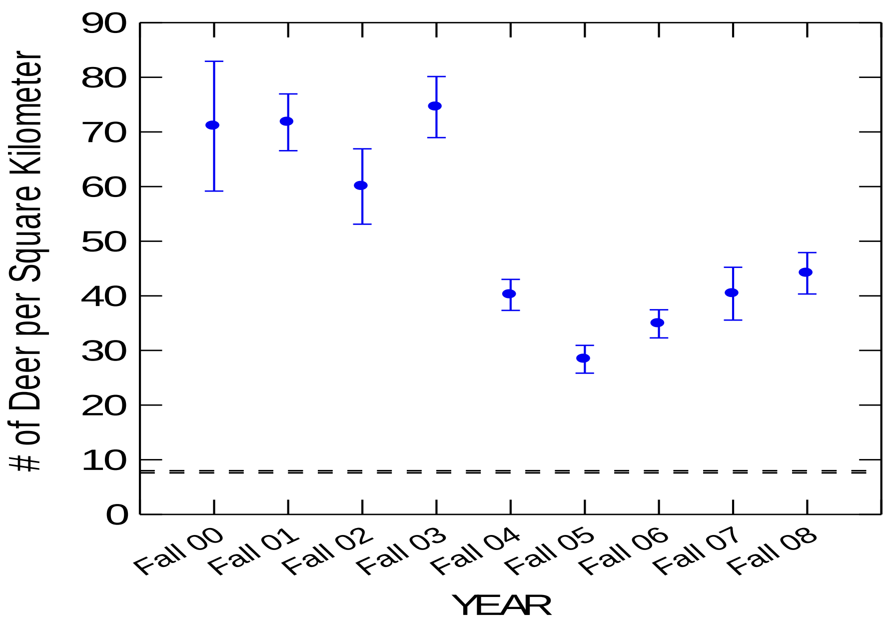

Figure 6. Catoctin Mountain Park annual deer density.

Catoctin has seen a modest increase in deer density since 2005. Deer density increased by 10% over 2007. The graph, at the time of this report, supports the traditional ungulate irruptive population paradigm where an initial irruption is followed by a recovery to a reduced carrying capacity (McCullough 1997).

CHOH- Gold Mine Tract

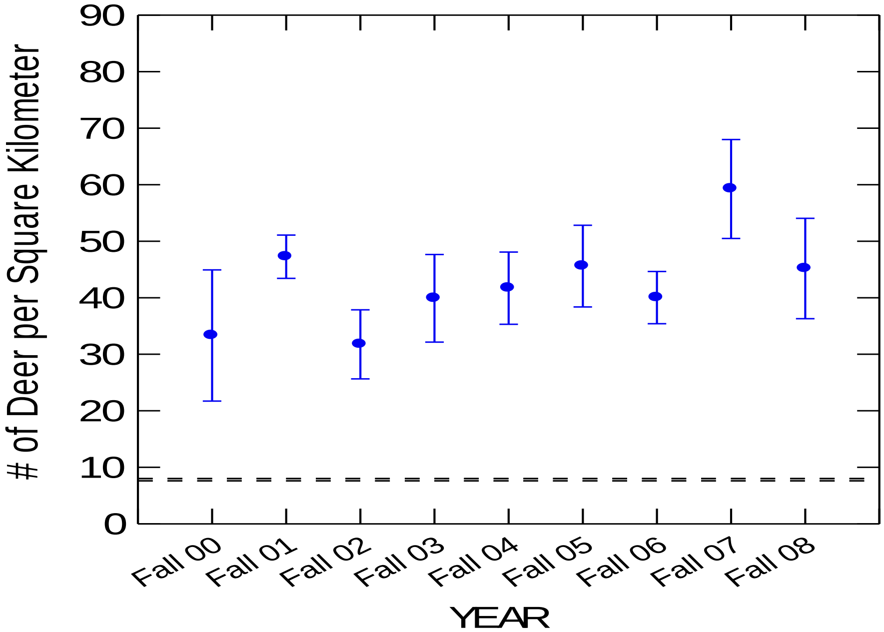

Figure 7. Chesapeake & Ohio Canal - Gold Mine Tract annual deer density.

The 2008 density at CHOH decreased by 19%. There was no significant population trend during the study period (2000-2008). The park has 100% power to detect a ±10% trend.

Prince William

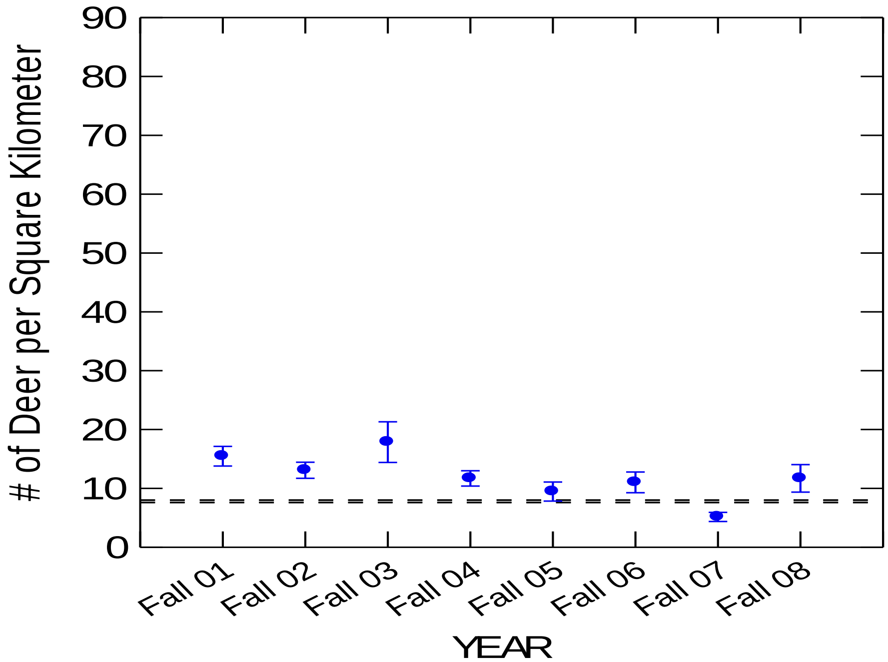

Figure 8. Prince William Forest annual deer density.

Density at Prince William increased by 127% in 2008. With the exception of 2003, the deer population has been less than 16 deer/square kilometer (40 per square mile). There is no longer a significant decreasing population trend at the park. Sampling variation and year-to-year variation account equally for the total count variation. It may take another 3 years of surveying before the park reaches 80% power to detect a ±10% trend.

Rock Creek

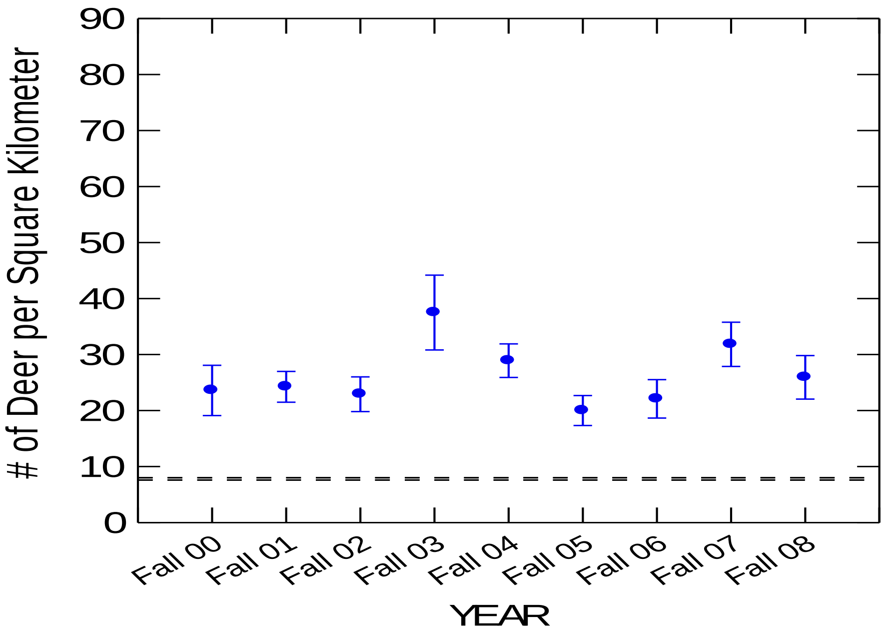

Figure 9. Rock Creek Park annual deer density.

Rock Creek experienced a 19% decrease in 2008. There have been no significant trends in the population. The park has 96% power to detect a 10% increase and 82% power to detect a 10% decrease.

GWMP- Great Falls

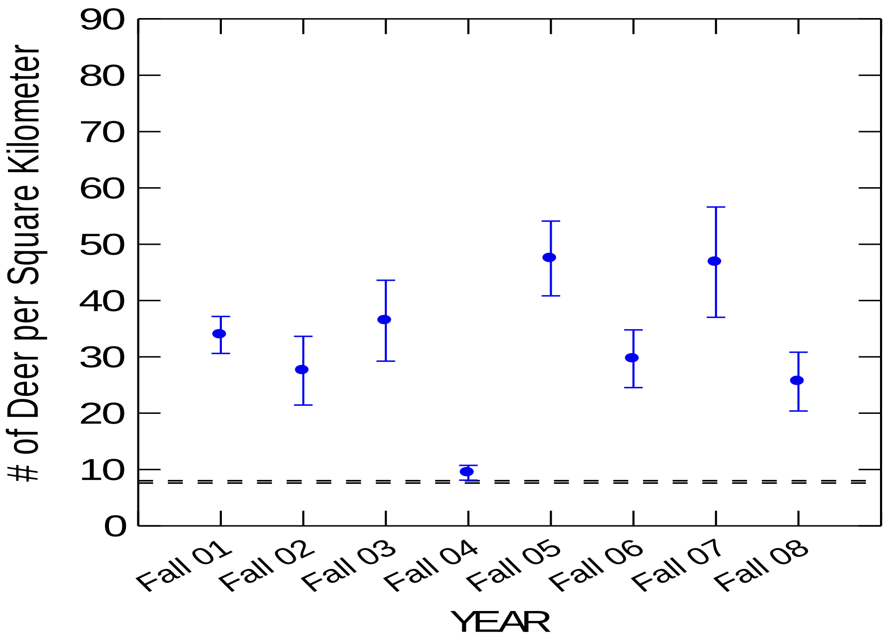

Figure 10. Great Falls annual deer density.

There was no significant trend in the deer population. The park also has 71% power to detect an increase of 10% and 54% power to detect a decrease of 10%. Year-to-year count variation was responsible for most of the total variation. This can be seen looking at the mean fall densities from 2001-2008 (33, 27, 36, 9, 47, 29, 47, 25). It may take another year of surveying before 80% power is achieved at the current level of survey intensity. The small size of the park and culling of deer at the adjoining county park contributes heavily to the count variation.

Harpers Ferry – Maryland Heights

There was a slight increase over 2007.

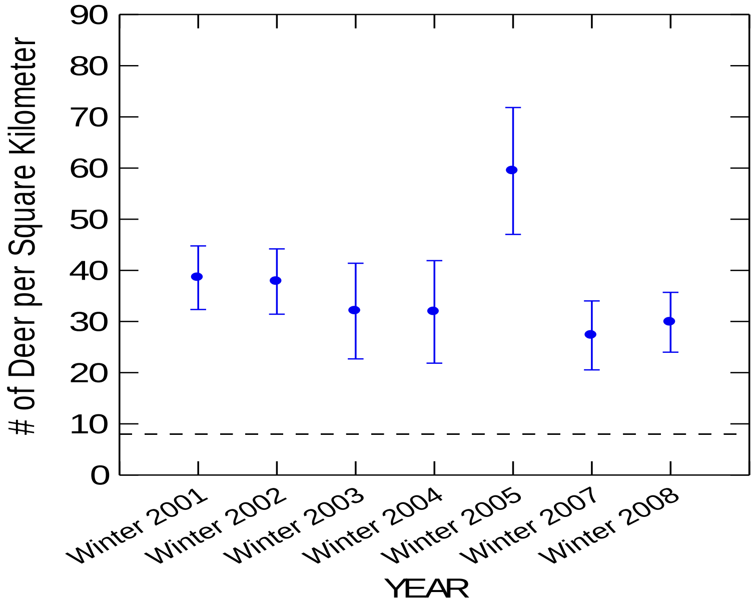

Figure 11. Harpers Ferry (Maryland Heights section) National Historic Park annual deer density.

Discussion

All parks had overabundant deer densities (over 20 per square mile or eight per square kilometer) that would negatively affect native vegetation. Catoctin is the only park with a statistically significant trend (decreasing). All parks should be preparing deer management plans as it is highly unlikely that these populations will be decreasing on their own.

Prince William should be developing a deer management plan in order to preserve the rich forest understory in the park. This will also make it more difficult for deer to completely remove the federally threatened small-whorled pogonia (*Isotria medeoloides*) from the park. There are also areas within the park that exhibit evidence of significant deer herbivory (subjective observations, NCR I&M vegetation monitoring team).

CATO has had a statistically significant negative trend at the 0.05 level for the last four years. This has no ecological significance as the deer density remains nearly six times higher than the acceptable density of 20 deer per square mile.

Two parks (Prince William and Great Falls, Va.) have not achieved 80% power to detect a ±10% trend. Greenbelt has not achieved 80% power to detect a 10% decrease.

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Appendix A. 2000-2008 Deer Densities (square kilometer) and Standard Errors of the Mean

Park	Fall 2000	Fall 2001	Fall 2002	Fall 2003	Fall 2004	Fall 2005	Fall 2006	Fall 2007	Fall 2008
ANTI	-	35.10±7.74	39.22±4.57	49.8±10.32	44.93±2.32	42.54±10.80	42.83±7.95	37.14±29.34	52.71±4.79
CATO	71.01±11.88	71.75±10.11	60.01±6.89	74.54±5.60	40.17±2.84	28.39±5.06	34.87±5.12	40.39±4.84	44.13±3.79
CHOH	33.33±36.90	47.26±3.83	31.76±6.11	39.90±7.75	41.70±6.39	45.60±7.23	40.03±4.61	55.97±8.75	45.17±8.88
GREE	-	33.90±4.44	23.88±5.72	41.79±9.11	40.02±6.59	39.84±11.87	38.88±7.41	32.09±6.44	39.14±14.79
GWMP	-	33.90±3.28	27.55±6.10	36.42±7.18	9.43±1.31	47.47±6.63	29.66±5.13	46.81±9.79	25.62±5.22
MANA	57.00±6.40	66.31±7.32	67.20±4.78	73.55±11.53	55.63±8.67	47.99±8.73	65.59±7.03	50.09±6.28	62.81±9.52
MONO	-	58.80±12.29	46.76±10.68	63.53±17.7	71.57±3.74	58.52±4.72	70.99±4.76	77.66±9.34	77.26±9.66
PISC	-	42.93±9.39	37.53±3.99	57.73±10.02	41.65±5.27	48.86±5.05	66.59±10.90	22.22±3.42	58.20±8.60
PRWI	-	15.47±1.67	13.09±1.36	17.86±3.45	11.70±1.30	9.46±1.62	11.03±1.76	5.14±0.77	11.70±2.34
ROCR	23.60±13.40	24.24±2.75	22.92±3.11	37.57±6.68	28.91±3.00	20.00±2.67	22.09±3.43	31.83±3.94	25.94±3.88
HAFE	-	38.56±12.43	37.81±12.77	32.04±18.61	31.89±20.03	59.43±24.80	No survey	27.29±13.64	29.85±11.7

The Department of the Interior protects and manages the nation’s natural resources and cultural heritage; provides scientific and other information about those resources; and honors its special responsibilities to American Indians, Alaska Natives, and affiliated Island Communities.

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